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WIRELESS FORKLIFT WITH OMNI-DIRECTIONAL MOVEMENT

MUHAMMAD AKMAL BIN MOHAMAD ROSLAN

A thesis submitted in partial fulfillment of the requirements for the award of the
degree of Bachelor of Engineering (Electrical - Mechatronics)

Faculty of Electrical Engineering
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MAY 2011

“I hereby declare that this thesis entitled “Wireless Forklift with Omni-Directional Movement” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Alhamdulillah, I finally complete and finish my final year project successfully. It helps me so much in understanding my previous lectures. Experience that I obtain from doing my final year project shall prove to be an asset in the pursuit of my studies as well as for my future career prospects.

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Last but not least, I would like to appreciate to my colleagues and others who provided assistance at various occasions involved either directly or indirectly in completing this project. Their views and tips are useful indeed. May Allah S.W.T bless for the cooperation and support.

ABSTRACT

Forklift is powered industrial truck used to lift and transport materials. Forklift has become indispensable equipment in manufacturing and warehousing operations. This project was implemented a mobile robot concept to the forklift. The mainly is about designing and fabricating forklift which is can move in omnidirectional movements and operated by PS2 wireless controller. This forklift can move freely in ten movements. PIC16f777 was act as a brain for this forklift to produce the output signal to control the forklift movements. Three transwheel was been used to make this forklift can move in omnidirectional movements and one servo motor to lift up and down the light object. To make it can control using PS2 wireless controller is by using SKPS module that can receive data from PS2 wireless controller and transmit to PIC16f777. This research has a great functions and benefits and can be proceed in the future.

ABSTRAK

Forklift merupakan salah satu trak industri berkuasa yang digunakan untuk mengangkat dan menyusun barang. Kini forklift telah dianggap sebagai peralatan yang amat penting untuk operasi di gudang dan kilang. Dalam projek ini, konsep robot mudahalih telah dilaksanakan pada forklift. Tujuan rekabentuk model robot ini adalah untuk membolehkan forklift bergerak “omnidirectional” dan kawal dengan menggunakan “PS2 wireless controller”. Forklift ini boleh bergerak dengan sepuluh arah. PIC 16f777 bertindak sebagai otak yang memproses maklumat dan member isyarat keluaran untuk mengawal operasi motor. Tiga “transwheel” tayar digunakan untuk membolehkan forklift bergerak “omnidirectional” dan satu servo motor untuk mengangkat dan menurunkan objek yang ringan. Modul SKPS digunakan untuk menerima maklumat dari “PS2 wireless controller” dan menghantar maklumat tersebut kepada PIC16f777 untuk diproses. Penyelidikan dalam bidang ini mempunyai fungsi yang hebat dan kebaikan serta dapat dilanjutkan di masa hadapan.

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LIST OF ABBREVIATIONS

DC	-	Direct Current
RC	-	Radio-Controlled
PIC	-	Programmable Interface Controller
PS2	-	Play Station 2
RM	-	Ringgit Malaysia
TTL	-	Transistor-transistor Logic
ICSP	-	In-Circuit Serial Programming
USB	-	Universal Serial Bus
UART	-	Universal Asynchronous Receiver/Transmitter
Li-Po	-	Lithium Polymer
W	-	Watts
V	-	Voltage
A	-	Ampere
kg	-	kilograms
cm	-	centimeter
s	-	Second
ms	-	millisecond
g	-	Gram

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Nowadays, forklifts have become an alternative in term to move loads from one place to another place. For instance forklift is widely being used in manufacturing industry. Forklift will make our work more efficiency and easier.

Omni-directional wheels have become popular for mobile robots because these wheels allow the mobile robot to drive on a straight path from a given location on the floor to another without any rotation needed by the mobile robot. Moreover, the mobile robot can arrive to its destination at the correct angle with combination of the rotation of these wheels.

In this project, the mobile robots that will be built are implementing using these two concepts. Forklift will be implementing with transwheels so it can move load in omni-directional movement and will be controlled using wireless joystick. The title of this project is wireless forklift with omni-directional movement.

1.2 PROBLEM STATEMENT

Most of forklift that use in manufacturing industry can only move forward and reverse, so it will have a problem to move a load when the forklift enter a narrow space. It also will take a time when the driver wants to adjust the forklift to go to the desired place. Therefore, this wireless forklift with omni-directional movement is designed to resolve this problem.

1.3 OBJECTIVE OF PROJECT

This project is carried out three objectives, the first objective of this project is to design and build a forklift that can lift-up and lift-down a load and carry the light object. This project is fabricated by applying the concepts and characteristics of the real forklift. The second objective is to make this forklift can move to all direction without rotate the wheels. The last objective is to design an operating system for forklift so this forklift can be control using wireless joystick.

1.4 SCOPE OF PROJECT

The scopes that states below is the guidelines that listed to ensure the project is conducted within its boundary of mechanical hardware, circuit design, and software design. This is to ensure that the objective of this project will achieve.

- Design mechanical and electronic hardware that will suit with software that will do developed.
- Using one servo motor to lift-up and lift-down a light object.

- The forklift will be equipped with transwheels to move all direction.
- Forklift that can be controlled using wireless joystick.

1.5 OUTLINE OF THESIS

This thesis consists of five chapters. In the first chapter, it discusses about project background, problem statement, objective, scope of this project. While in the Chapter 2 will discuss about the literature review that have been done. The next chapter is Chapter 3 that will reveal the detail of research methodology that use in this project. In addition contains of chapter 3 will be included mechanical, electronic and software design. The result and discussion about of this project will be discussed in the Chapter 4. Last but not least, Chapter 5 discusses the conclusion of this project and recommendation of the future work that can be done.

1.6 SUMMARY OF WORKS

Gantt charts as shown in Table 1.1 and Table 1.2 below, show the planning schedule of the work in final year's first semester and second semester respectively.

Task/Week	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Topic Research							Hari Raya Break and Mid Sem Break							
Proposal														
Literature Review														
Circuit design														
Hardware Part's Purchase														
FYP1 Presentation														
Report writing														

Table 1.1: Gantt chart FYP 1

Task/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Hardware Completion																			
Software Implementation (Omniwheel)																			
Software Implementation (Forklift)																			
Thesis Writing																			
FYP2 Presentation																			
Report writing																			

Table 1.2: Gantt chart FYP 2

CHAPTER 2

LITERATURE REVIEWS

2.1 INTRODUCTION

This chapter are reviewing the similar project according to my project. This similar project will be my guideline to this project. Literature review of this project are divided into two parts, first part is about forklift and the other part about omni-directional robot. This chapter is important because this is my reference to start and during I doing this project.

2.2 WIRELESS FORKLIFT BY ABDUL AZIZ

A wireless forklift was built by Abdul Aziz Bin Abdul Rahman in his undergraduate project in year 2010. Figure 2.1 below shows the picture of wireless forklift.

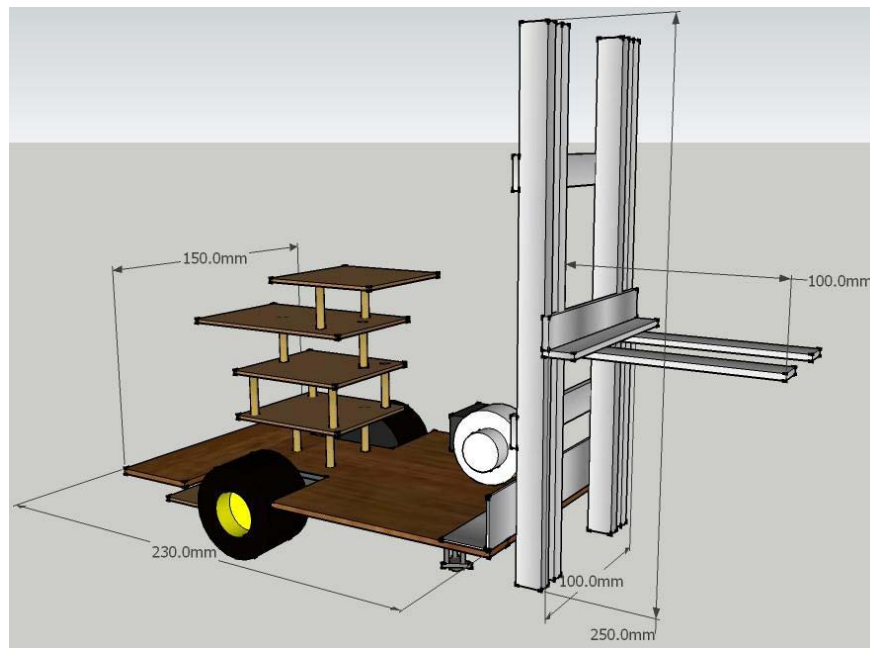


Figure 2.1: Wireless forklift By Abdul Aziz

This wireless forklift consist Tamiya Twin-Motor Gearbox DC Motor, one Hextronix HX5010 Servo Motor, and Bluetooth Module. This forklift use Tamiya Twin-Motor DC Motor to move forward and backward, and to lift-up the load, Hextronix HX5010 Servo Motor are been used. Microcontroller that been use as the brain to this forklift is PF16f877A. This wireless forklift are capable to move forward, backward, turn right and left by controlling using laptop, the Bluetooth Module will connect with laptop and receive a command from the laptop and will give the information to the microcontroller. The weight of load that this wireless forklift can lift-up is around 100 grams and dimensions of 6 x 7 x 11 cm.

2.3 UNMANNED AUTONOMOUS FORKLIFT

This unmanned autonomous forklift is a standard industrial forklift that produced by the CLARK Company and name as CRX-10. The CRX-10 forklift is shows in Figure 2.2.



Figure 2.2: Clark CRX-10 forklift equipped with sensors

This unmanned forklift are mounted with four wheels include one small caster wheel at the right rear side and two caster wheel at the front side, and one main wheel at the left rear side for controlling the direction of the forklift. These forklifts have ability for dual operations that is unmanned mode and manual mode. For unmanned mode, order motions are generated based on information provided by some sensor pose.

2.4 COOPERATIVE MULTI AGENT SOCCER ROBOT TEAM

This robot has been designed to enter a RoboCup mobile robot competition and the objectives of this competition are a robot must be prepared to accelerate in an appropriate direction, recognize ball and the others robot swiftly, can kick ball with sufficient velocity, and with proper accuracy. To achieve the characteristics of this robot, two type of multi agent soccer robot team have been design which is three-wheel triangle robot and four-wheel Cartesian robot that are shows in Figure 2.3. According to the different maneuvers of the two robots, a team from both types of robot can have more flexibility and powerful mobility.

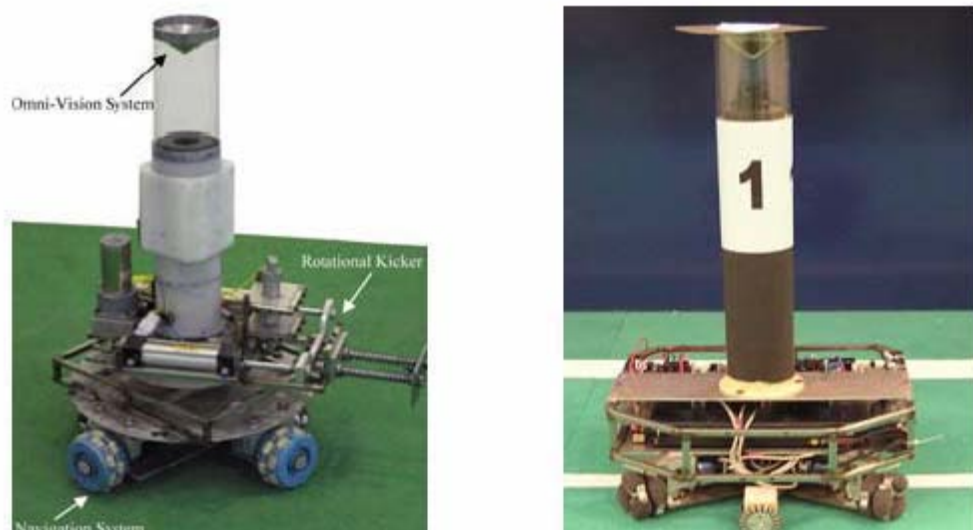


Figure 2.3: Right side is 3-wheel robot and left side is 4-wheel robot

Three 80 W DC servomotors are used on three-wheel triangle robot. Based on the physical characteristic robot, the maximum speed acceleration is 2m/sec and 3m/sec² appropriate. Robot with three-wheel mechanism is quite faster and more flexible in order to reach the ball and the desire orientation. To kick the ball, spring that capable of compressing and releasing has implemented.

Second type of robot is consists four omniwheels and rotational kicker part. Each omniwheels are supported with one DC servo motor that can make the robot move. The movement of this robot is according from the result of the comparative generating motors, thus each pair of wheels will force robot to move. And for the system kicks, on top of this robot can turn 360 degrees that can enables the robot to optimize the way to reach the ball with necessary orientation for the right kick. This will saves time and also simplify the rotation of the robot control algorithm, which is a significant advantage of this robot.

2.5 FLEXIBOT-USING TRANSWHEEL

The Flexibot is a three transwheels mobile robot which is allows Flexibot to move in any direction without having turn relative to the robot base. For example to move sideways, normal mobile robots need to turn 90 degrees, move forward, and then turn back to its original direction. But using this Flexibot, it can execute a single sideways motion, and further can easily track a moving object while maintaining a required orientation with respect to it. This Flexibot is an autonomous robot, it have a push button to select the mode of movement of the Flexibot. Furthermore this Flexibot have LCD display to display the current mode and the situation. The Figure 2.4 below shows the picture of Flexibot-Using Transwheel.

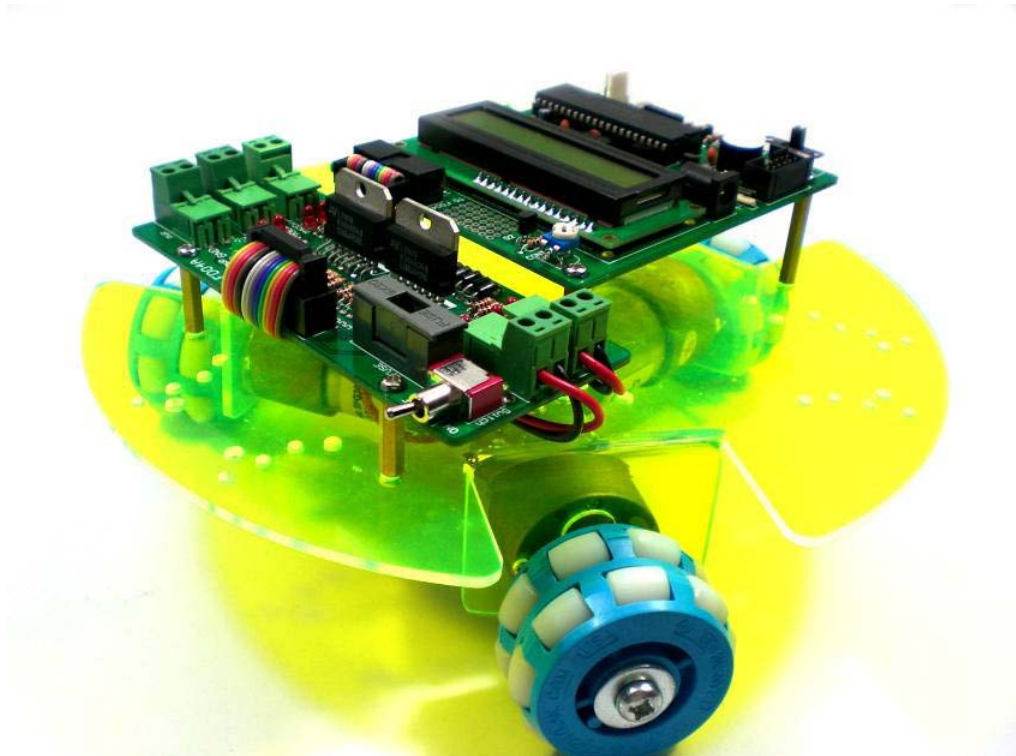


Figure 2.4: Flexibot-Using Transwheel

2.6 ATX-SERIES OMNI-DIRECTIONAL FORKLIFT

Airtrax ATX-3000 Industrial forklifts excel in applications requiring tight maneuvering or transporting long roads sideways. The ATS's unique, Omni-Directional movement allows it to travel in all directions thus making it an ideal vehicle to work in tight spaces where turns are not possible and finite control is a must. The truck feature 48 volt transistor controls with state of the art technology, infinitely variable travel, lift and lower speeds, excellent visibility, ergonomic controls and operator comfort. The Figure 2.5 below shows the picture of the ATX-Series Omni-Directional Forklift.



Figure 2.5: Airtrax ATX-3000 Forklift

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will discuss about process in designing robot. This project is divided into two parts, hardware design and software design. This project must be done step by step follow the flow such as shows in Figure 3.1 in order to achieve the objective of the project.

Idea and the concept to do this project is was inspired by the unique of transwheel that can move in all direction by controlling the speed of motor, and to make it the forklift can do the work in a narrow space environment.

In the beginning of this project, various sources have been collected such as journals, past year thesis from library utm and internet.

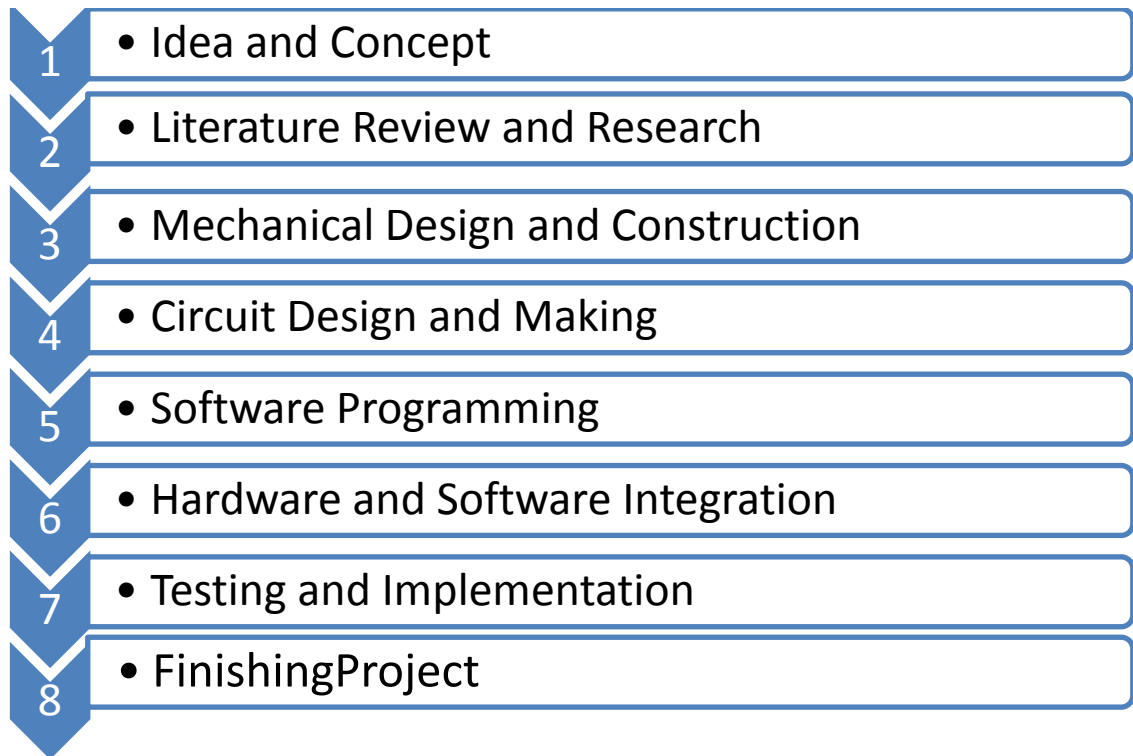


Figure 3.1: Step taking in developing wireless forklift with omni-directional movement

3.2 MECHANICAL STRUCTURE DESIGN

The mechanical design of the base and the fork arm of wireless forklift with omni-directional movement was design using SolidWorks. Figure 3.2 and Figure 3.3 below shows the design of the base and fork of the forklift. Figure 3.4 shows the combination of base and the fork arm.

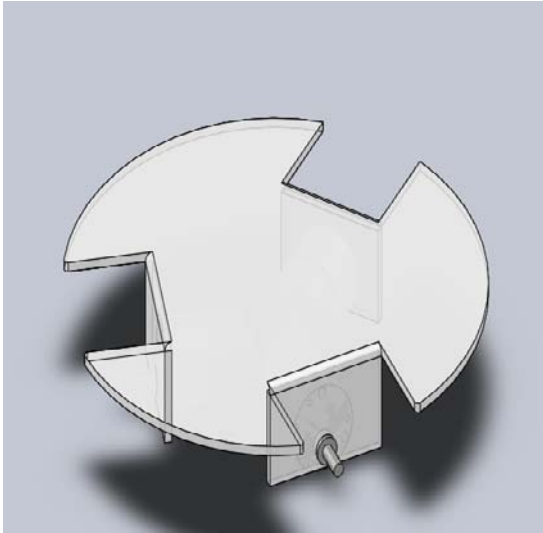


Figure 3.2: Base design

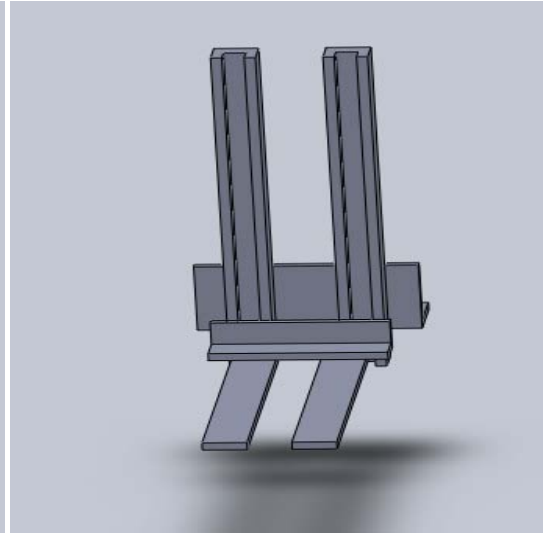


Figure 3.3: Fork arm design

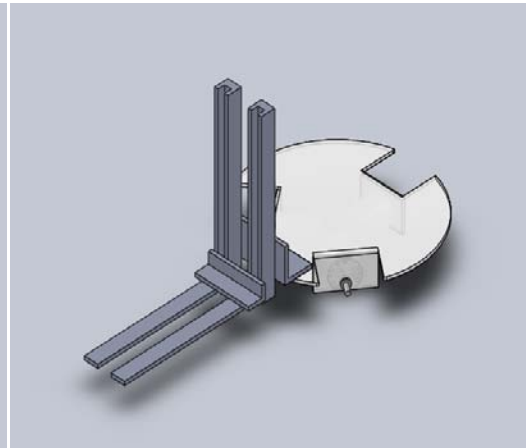
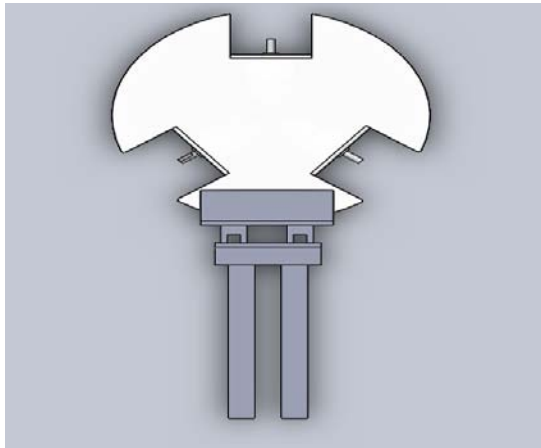


Figure 3.4: Complete mechanical design of forklift

The design of forklift is to have a capability to move in all direction smoothly and can do a simple task to lift-up an object by using its fork arm. In order to achieve that target, design of the mobile robot and forklift has been studied. The dimension of the base that will be used in this project is shown in Figure 3.5. And in Figure 3.6 shows the picture of base that has been done and the material was used to build the base is prospect.

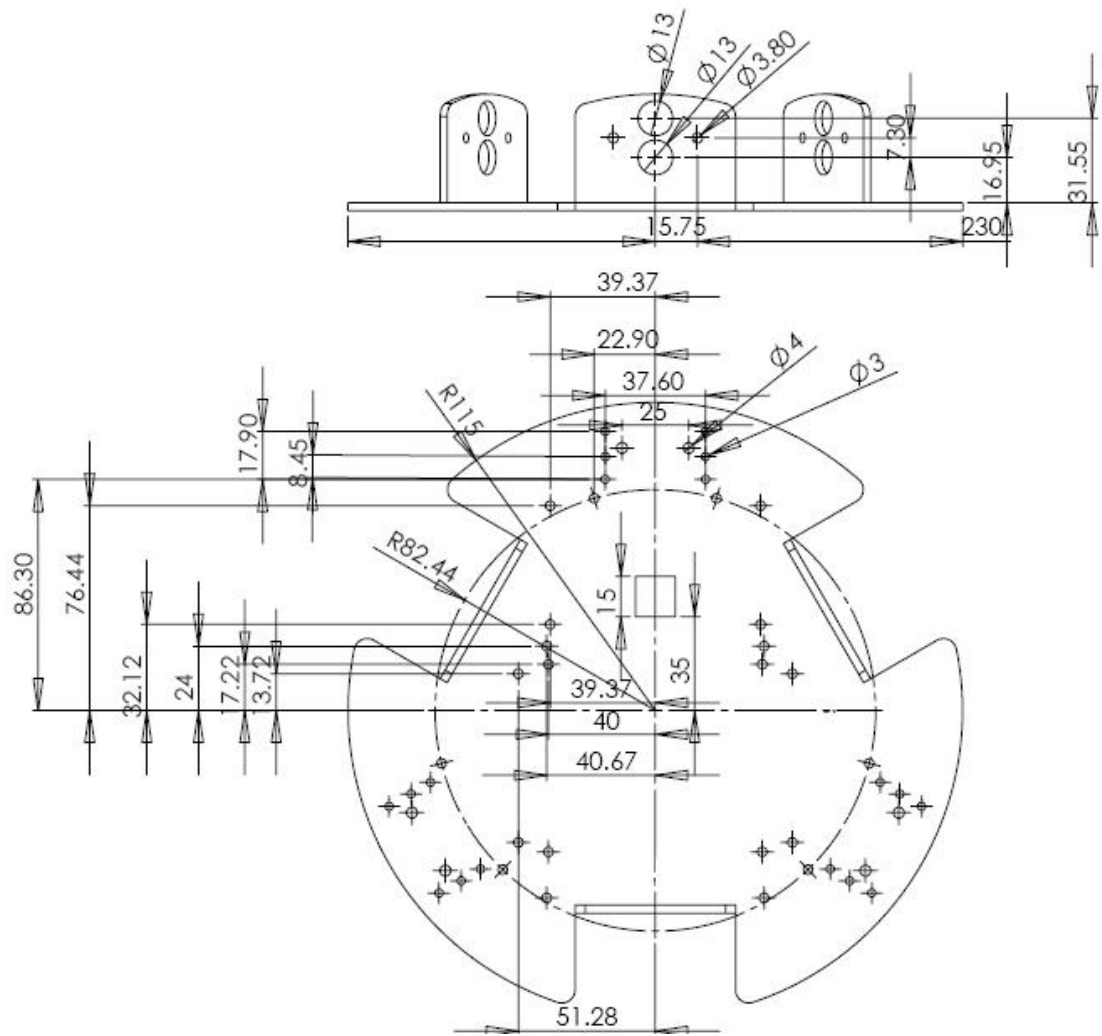


Figure 3.5: Dimension of base design



Figure 3.6: The base

3.2.1 DC GEARED MOTORS (MO-SPG-30-20k)

The locomotion of the wireless forklift was achieved by utilizing DC geared motor to each transwheels. The model of the motor was used is MO-SPG-30-20K, bought from *Cytron Technologies*. The rated voltage of this motor is DC 12V and its maximum current rating is 300mA. In addition, the flexible rated speed at 185 RPM and rated torque at 78.4mN.m were offered by this model of DC geared motor.

The unit price of this DC geared motor is RM70. In this project, three DC geared motors have been used thus it costs me RM210. Figure 3.7 shows the picture of a MO-SPG-30-20K geared motor.



Figure 3.7: DC Geared Motor MO-SPG-30-20K

3.2.2 RC SERVO MOTOR (C55R)

Servos are controlled by sending them a pulse of variable width. The signal wire is used to send this pulse. Inside a typical RC servo contains a small motor and gearbox to do the work, a potentiometer to measure the position of the output gear, and an electronic circuit that controls the motor to make the output gear move to the desired position. Because all of these components are packaged into a compact, low-cost unit, RC servos are great actuator for robots.

C55R RC Servo Motor is designed for closed feedback control. The pulse width range of this servo is from 0.5ms – 2.5ms. The dimension and picture of C55R servo motor are shows in Figure 3.8 and 3.9. The weight of this servo motor is 55g and the gear material that provide in this motor is metal gear. Furthermore, the speed and torque of this servo motor can reach are 0.22(s/60⁰) speed and 9.00(Kg.cm) for 4.8V operation, 0.20(s/60⁰) speed and 11.00(Kg.cm) torque for 6.0V operation and last but not least 0.17(s/60⁰) speed and 13.00(Kg.cm) torque for 7.0V operation. Figure 3.10 shows the specification on servo motor. One C55R servo motor has bought from *Cytron Technologies* that costs me RM 80.

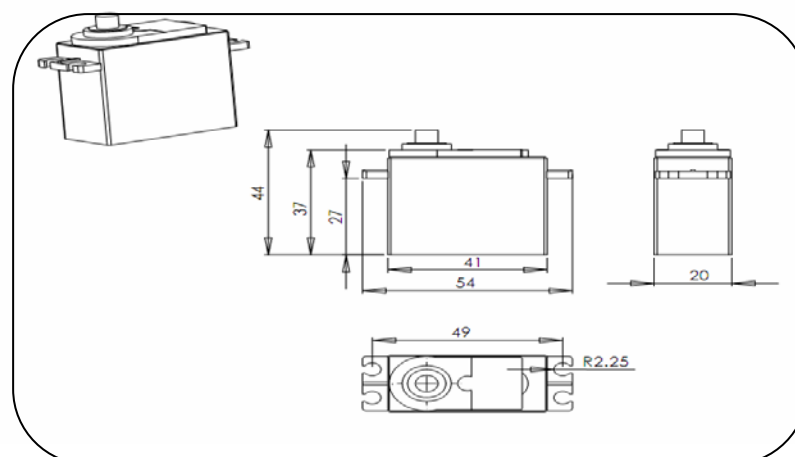


Figure 3.8: Dimension of RC Servo Motor C55R



Figure 3.9: RC Servo Motor C55R

Specification		Servo Motor Model		
		C36R	C40R	C55R
4.8V	Speed (s/60°)	0.16	0.19	0.22
	Torque (Kg.cm)	3.5	6.00	9.00
6.0V	Speed (s/60°)	0.14	0.16	0.20
	Torque (Kg.cm)	4.50	7.00	11.0
7.0V	Speed (s/60°)	-	-	0.17
	Torque (Kg.cm)	-	-	13.00
Signal To Control Angle		TTL PWM	TTL PWM	TTL PWM
PWM At Min Angle (ms)		0.5	0.54	0.582
PWM At Max Angle (ms)		2.35	2.40	2.50
Operating Voltage (VDC)		4.8-6.0	4.8-6.0	4.8-7.0
Operating Frequency (Hz)		50.0	50.0	50.0
Moving Range(degree)		0-180	0-180	0-180
Wiring (Black/Brown Wire)		Ground	Ground	Ground
Wiring (Red Wire)		4.8-6.0	4.8-6.0	4.8-7.0
Wiring (Orange/Other Wire)		PWM signal	PWM signal	PWM signal
Dimension (mm)		~ 40.2x19.8x36	~ 40.2x19.8x36	~ 41x20x37
Weight (g)		36.0	38.0	55.0
Gear material		Plastic Gear	Plastic Gear	Metal Gear
Servo type		Standard	Standard	Standard

Figure 3.10: Specification of Servo Motor

Servos are controlled by sending them a pulse of variable width. Pulse Width Modulation is the pulse that applied to servo motor to determine the angle of servo motor. The complete cycle for servo is 20ms, Figure 3.11 shows the square wave signal of servo motor. How far the motor turns was determined by the length of the pulse. An example, if a 1.5ms pulse sends to servo, it will make the motor turn to the 90 degree position (neutral position).

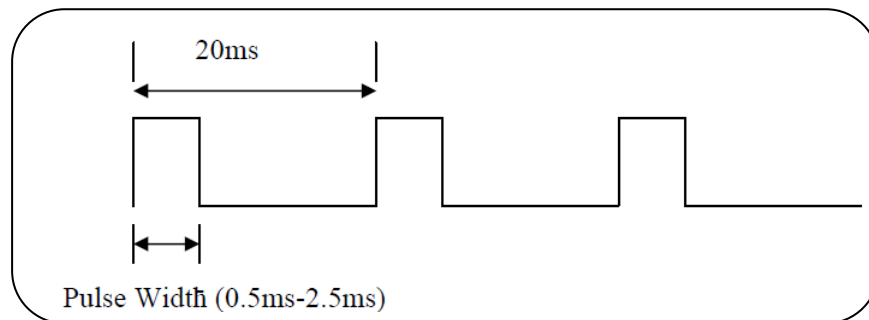


Figure 3.11: Signal of Pulse Servo Motor

The position pulse must be repeated to make the servo stay in that position. The servo will rotate anticlockwise if the pulse sent to servo is less than 1.5ms. Hence to make servo rotate clockwise, the pulse that sent to servo must be higher than 1.5ms. However there is a minimum and maximum pulse that can send to servo otherwise servo motor will be damaged. The minimum pulse can be sent is 1ms and the maximum pulse is 2.5ms. Figure 3.12 shows the rotation of servo for the pulse given.

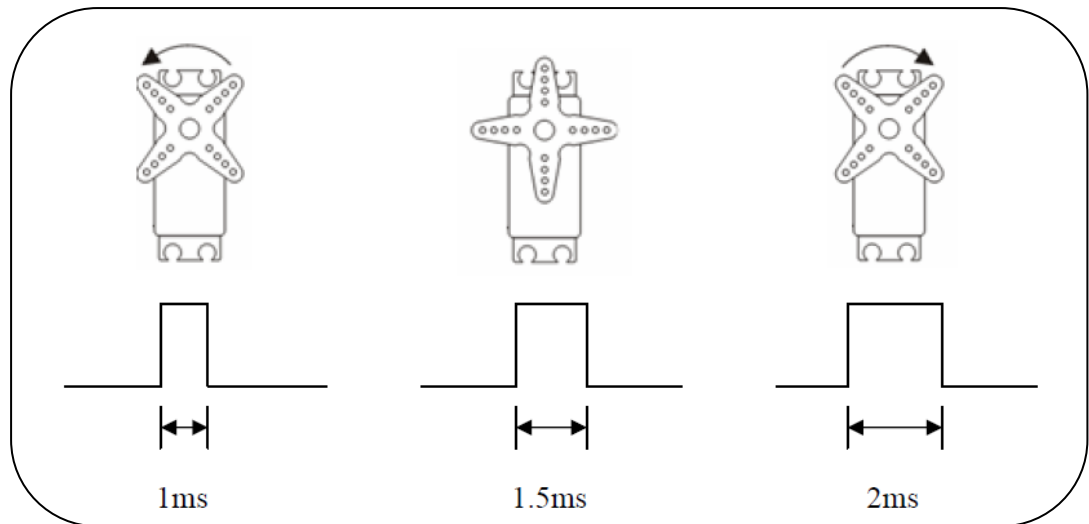


Figure 3.12: Rotation of Servo Regarding The Pulse Given

3.2.3 TRANSWHEEL

Three transwheels were used and attached to the base of the forklift and the DC geared motor. Transwheel is unique wheel, it can make mobile robot moving in all direction by controlling the speed of the DC motor. Transwheel are place in sequence 120° around the base. Each transwheel are attached to the coupling before attached to the DC geared motor. Transwheel and coupling also have been bought from *Cytron Technologies* with RM70 per unit and RM20 per unit. In my project, I use three transwheels so it costs me RM210 for this wheel and RM60 the coupling. Figure 3.13 shows the picture of the transwheels.



Figure 3.13: Transwheels

3.3 ELECTRONIC AND CIRCUIT DESIGN

In the electronic and circuit design, the first step is must to understand the requirements of the project and the limitation of various constraints like the level of technology, reliability of microcontroller and the complexity of programming codes and interfacing devise. By using datasheet that search using internet, analyze about the component that want to use in the project and by using reference from the previous researcher. Circuit designs are drawn by using Proteus software.

3.3.1 POWER SUPPLY CIRCUIT

Two type of power supply circuit (voltage regulator circuit) are used in this project. The output voltage that supplies 5 volt and 6 volt will be used. Power supply with 5 volt output will be used to supply on main circuit, motor driver circuit and to PS2 controller starter kit. To make a +5 volt power supply, LM7805 voltage regulator has been used and in the Figure 3.14 shows the circuit of 5V voltage regulator.

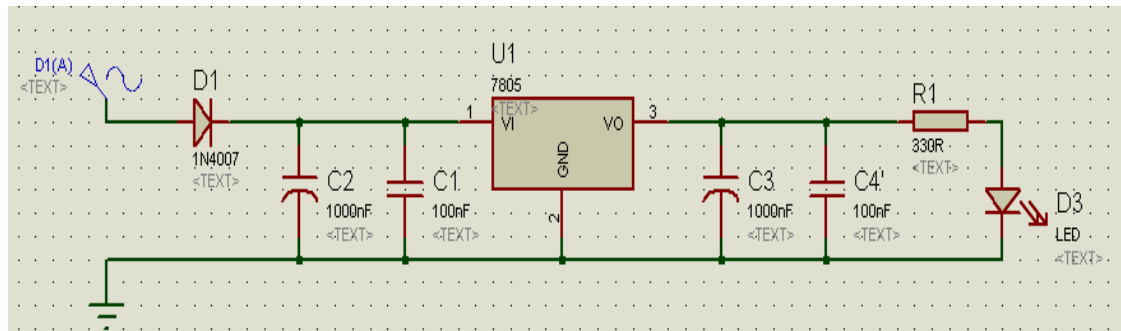


Figure 3.14: Voltage regulator circuit with 5 volt output

Another power supply is 6 volt output voltage regulator. To make it can produce +6 volt, LM7806 voltage regulator has been used and Figure 3.15 shows the circuit design of 6 volt voltage regulator. Figure 3.16 shows the main circuit that consist PIC circuit and 5 volt and 6 volt voltage regulator that has been built.

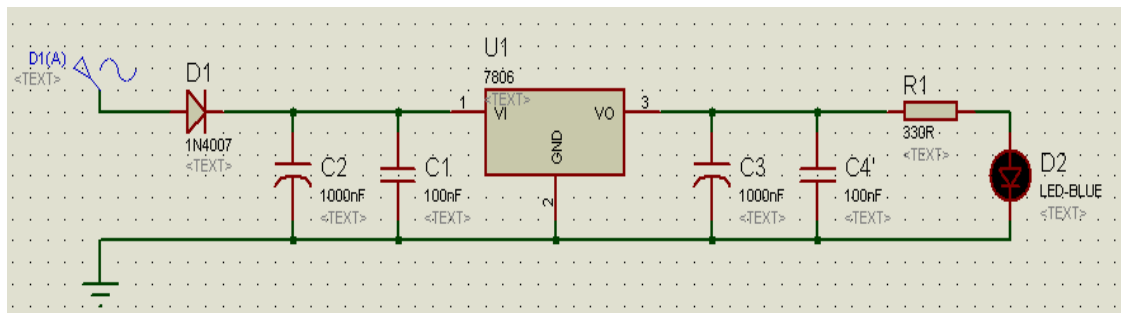


Figure 3.15: Voltage regulator circuit with 6 volt output

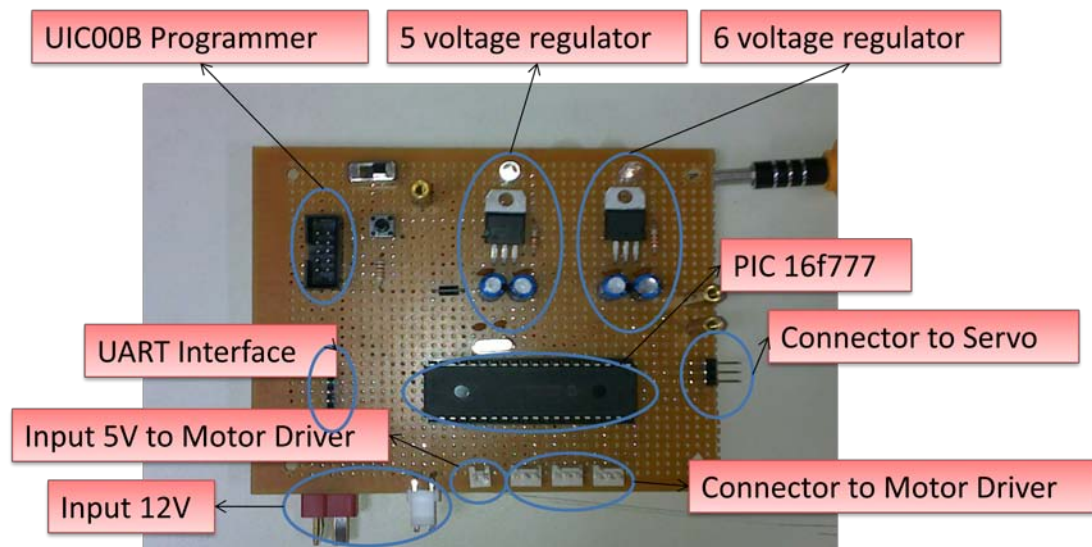


Figure 3.16: Main Circuit

Power supply that used to supply the voltage regulator circuit is Lipo battery 11.1 volt DC. Sometimes the input supply may be noisy. To overcome this problem and to get a better 5 volt and 6 volt output, capacitor is added to the circuit.

3.3.2 LIPO BATTERY

Lithium Polymer or Lipo battery is a type of rechargeable battery. In this project, I use two 11.1V Lipo batteries. One of battery is used for two DC geared motor and another one is used to one DC geared motor and to both voltage regular to supply power to circuit. Figure 3.17 shows the picture of Lipo battery.



Figure 3.17: 11.1 Lipo Battery

3.3.3 I/O PIN ASSIGNATION OF PIC16F777

Microcontroller is used in this project because of its small size, low cost but high performance. Microcontrollers is combination microprocessor, memory, I/O ports and other special function registers such as timer, ADC, PWM and interrupt.

PIC16F777 was selected as microcontroller that will be used in this project. Figure 3.18 shows the picture of PIC16F777, Figure 3.19 pin diagram of PIC16F777 and Table 3.1 shows the features of this microcontroller.



Figure 3.18: Dual-In line type PIC16F777

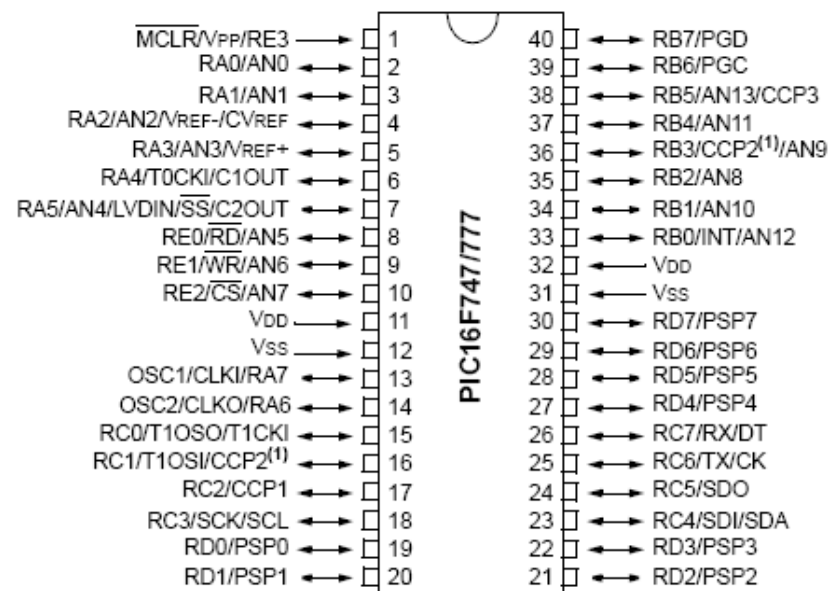


Figure 3.19: Pin Diagram of PIC16F777

Key Features	PIC16F777
Operating Frequency	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	8K
Data Memory (bytes)	368
Interrupts	17
I/O Ports	Ports A, B, C, D, E
Timers	3
Capture/Compare/PWM Modules	3
Master Serial Communications	MSSP, AUSART
Parallel Communications	PSP
10-bit Analog-to-Digital Module	14 Input Channels
Instruction Set	35 Instructions
Packaging	40-pin PDIP 44-pin QFN 44-pin TQFP

Table 3.1: PIC16F777 Device Features

3.3.4 L298 MOTOR DRIVER

If a DC motor is connected directly to the battery, DC motor will be provided with a constant power all the time. Due to this constant power, the speed of motor will slow down or speed up regarding the load it takes. If the load is heavier the speed of motor will be slow down and speed up when the load is lighter. Hence, DC motor driver is needed which is it can control the magnitude of supply voltage in order to control the speed of DC motor.

Motor Driver L298 is used in the main circuit as driving chip of three DC geared motors. This motor driver gives a high voltage, high current dual full-bridge driver designed to accepted TTL logic levels and drive inductive loads such as

relays, solenoids DC and stepping motors. This motor driver allows a total of 4A high current to pass through it during operation. Table 3.2 below shows function of each pin of chip L298.

Pin	Name	Function
1;15	Sense A; Sense B	Between this pin and ground is connected the sense resistor to control the current of the load.
2;3	Out 1; Out 2	Outputs of the Bridge A; the current that flows through the load connected between these two pins is monitored at pin 1.
4	Vs	Supply Voltage for the Power Output Stages. A non-inductive 100nF capacitor must be connected between this pin and ground.
5;7	Input 1; Input 2	TTL Compatible Inputs of the Bridge A.
6;11	Enable A; EnableB	TTL Compatible Enable Input: the L state disables the bridge A (enable A) and/or the bridge B (enable B).
8	GND	Ground.
9	Vss	Supply Voltage for the Logic Blocks. A100nF capacitor must be connected between this pin and ground.
10;12	Input 3; Input 4	TTL Compatible Inputs of the Bridge B.
13;14	Out 3; Out 4	Outputs of the Bridge B. The current that flows through the load connected between these two pins is monitored at pin 15.

Table 3.2: Pin Function of Chip L298

I have bought two of L298 motor driver at RS Component Company that cost me RM16.50 per unit and total is RM33. Figure 3.20 below show the pin diagram and picture of L298 motor driver and Figure 3.21 is show the circuit design L298 motor driver. In the Figure 3.22 shows the motor driver circuit that has been built.

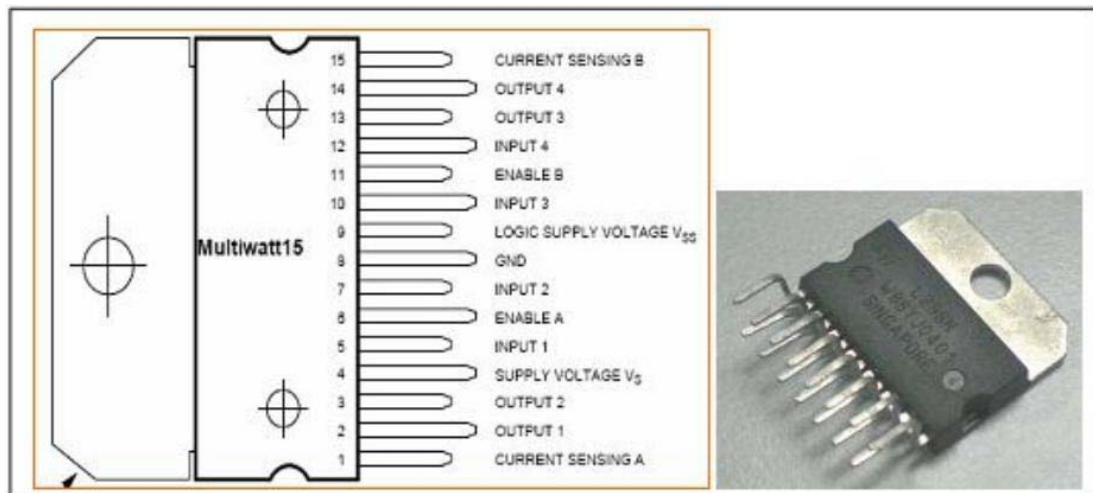


Figure 3.20: Left side is the pin diagram and right side is picture of L298 motor driver

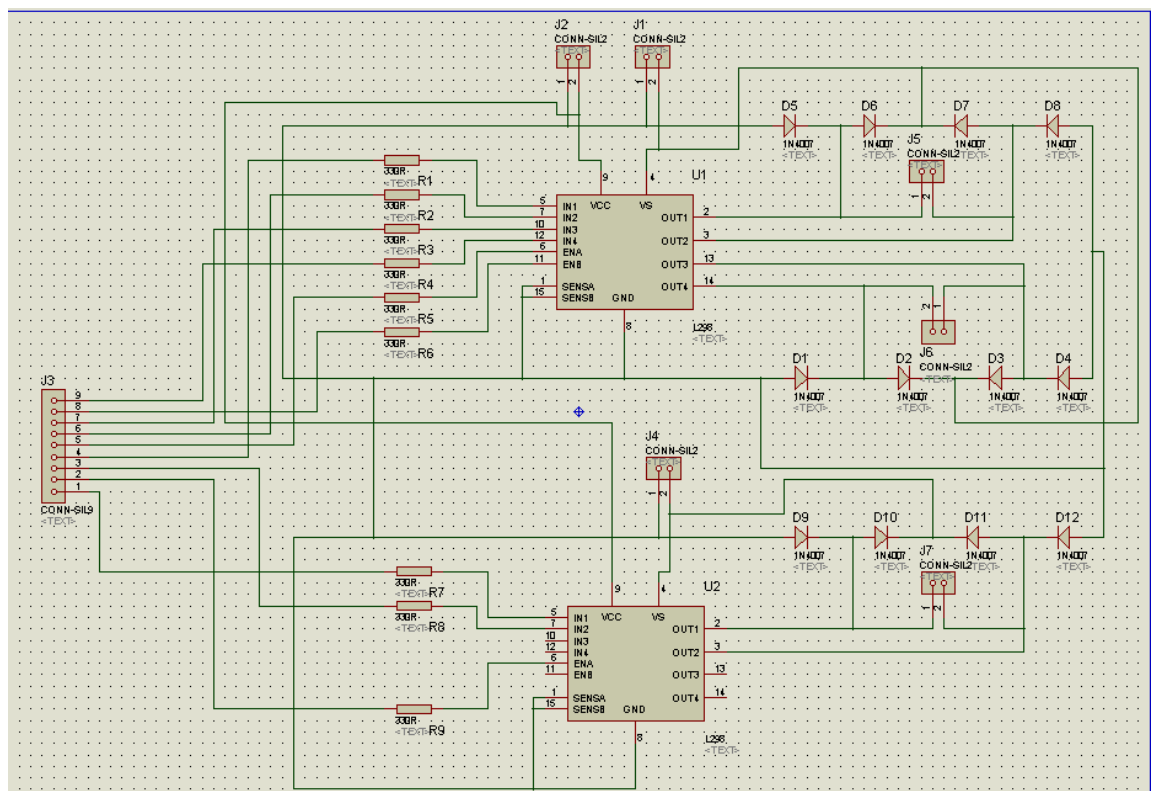


Figure 3.21: Circuit Design of L298 Motor Driver

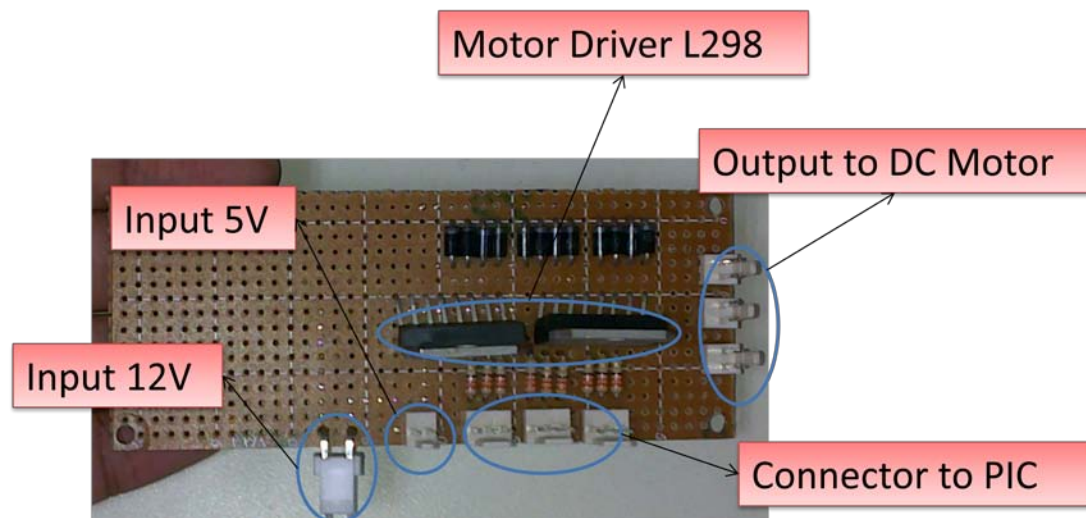


Figure 3.22: Motor Circuit Driver

3.3.5 PS2 CONTROLLER STARTER KIT

Play station 2 (PS2) controllers is relatively easy to obtain from any game store and it offers good human manual input for control system. More and more developers are looking into applying existing PS2 controller to control particular system. On my project, PS2 Controller Starter Kit will be used to connect wireless joystick and the main circuit to control this forklift movement. The feature of this circuit is 5V powered, low current consumption, less than 150mA. This controller is communicating with host microcontroller through UART. The prices that sell at *Cytron Technologies* is RM99.90. Figure 3.23 shows the circuit of PS2 Controller Starter Kit and its functions describe in Table 3.3

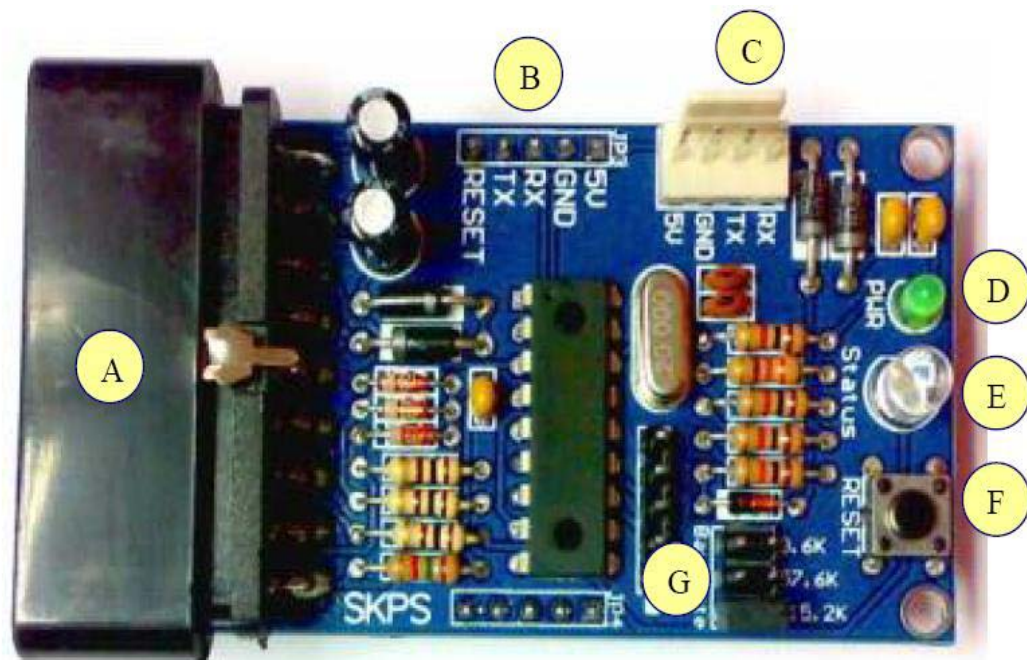


Figure 3.23: SKPS PS2 Controller Starter Kit

Label	Function
A	PS2 connector socket, please connect the PS2 controller here
B	5 ways header pin for external power and UART interface to microcontroller.
C	4 ways 2510 header pin for external power and interface to PC or microcontroller also (depends to user).
D	On board power indicator LED (Green)
E	On board indicator LED (Blue) indicators for check connection with controller status.
F	On board reset button for SKPS.
G	Baud rate selector.

Table 3.3: SKPS PS2 Controller Starter Kit Function Description

3.3.6 PS2 WIRELESS CONTROLLER

PS2 wireless controller is controller that uses to control the movement of Wireless Forklift with Omni-directional Movement. In this project, I have assigned the button that need to push to move the forklift. The Figure 3.24 shows the PS2 wireless controller with receiver. The price of this PS2 wireless controller and the receiver is RM70.



Figure 3.24: PS2 Wireless Controller with receiver.

3.4 PROGRAMMING DESIGN

After finishing mechanical and electronic circuit part, the attention has been shift to the programming development. There are two type of software were used in this project which is MPLAB IDE to write a program and convert to the hex file that the language that PIC microcontroller use and the other one is PICKit2 is to load the hex file into the PIC microcontroller. Figure 3.25 illustrate the MPLAB IDE compiler interface.

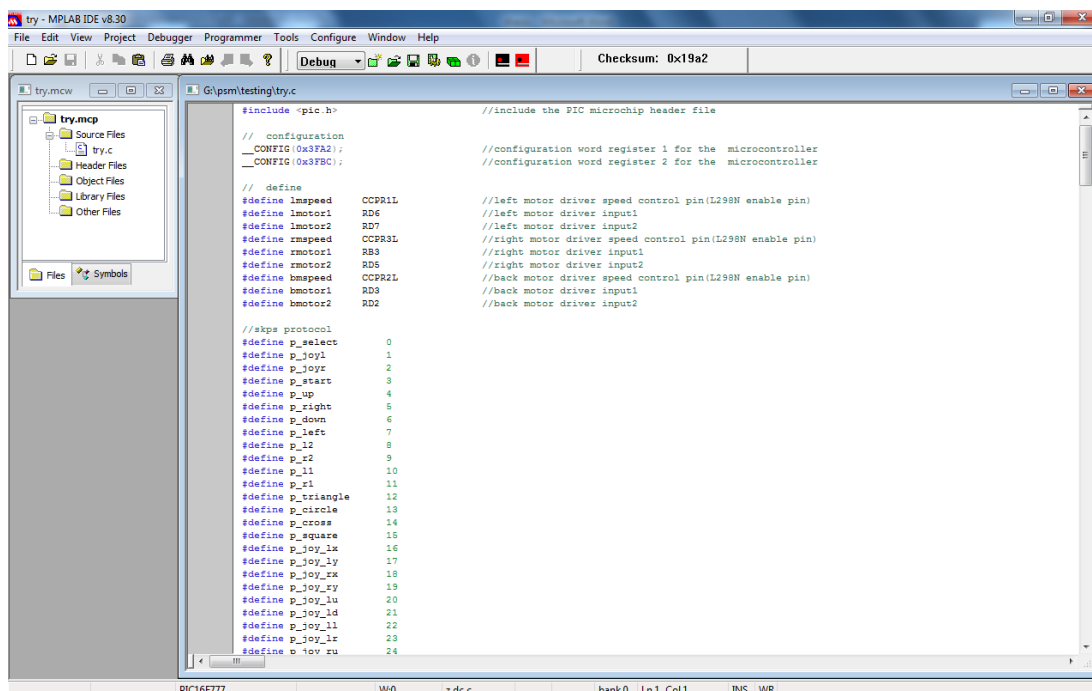


Figure 3.25: MPLAB IDE compiler interface

C-language is chosen as the programming language for this project due to the memory size of C-language is small and easy to understand. MPLAB IDE software that use in this project was employed to write the C-language programming. USB ICSP PIC programmer is use together with PICKit2 software to load the hex file into

the PIC microcontroller. Figure 3.26 illustrate, the PICkit2 software and Figure 3.27 shows the circuit of USB ICSP PIC programmer.

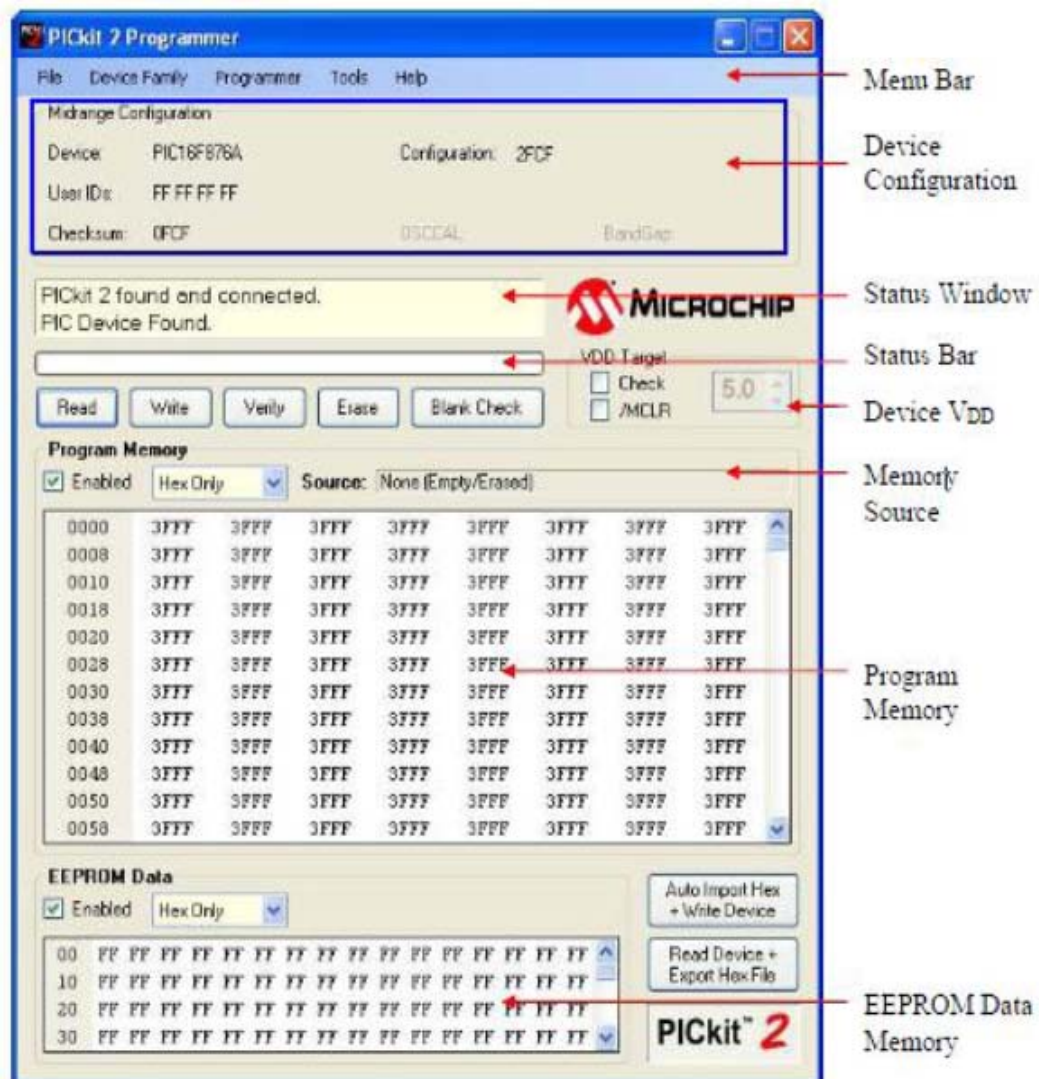


Figure 3.26: PICkit2 Programmer Interface

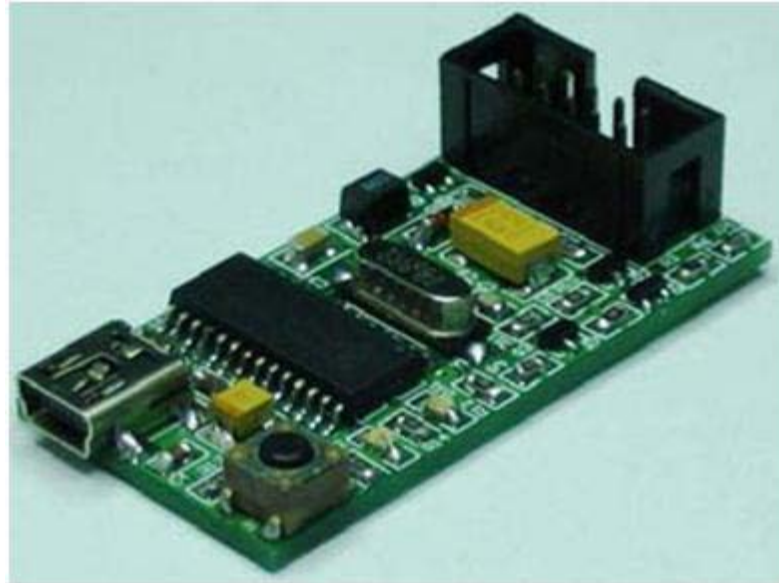


Figure 3.27: USB ICSP PIC Programmer.

Flow chart that show the basic process of software programming design is illustrate in the Figure 3.28. Note that in the flow chart, there are joy_lu, joy_ld, joy_rr and joy_rl. This variable is being name according to the standard format.

Joy_XX

'l' means left joystick
'r' means right joystick

'u' means up-axis
'd' means down-axis
'r' means right-axis
'l' means left-axis

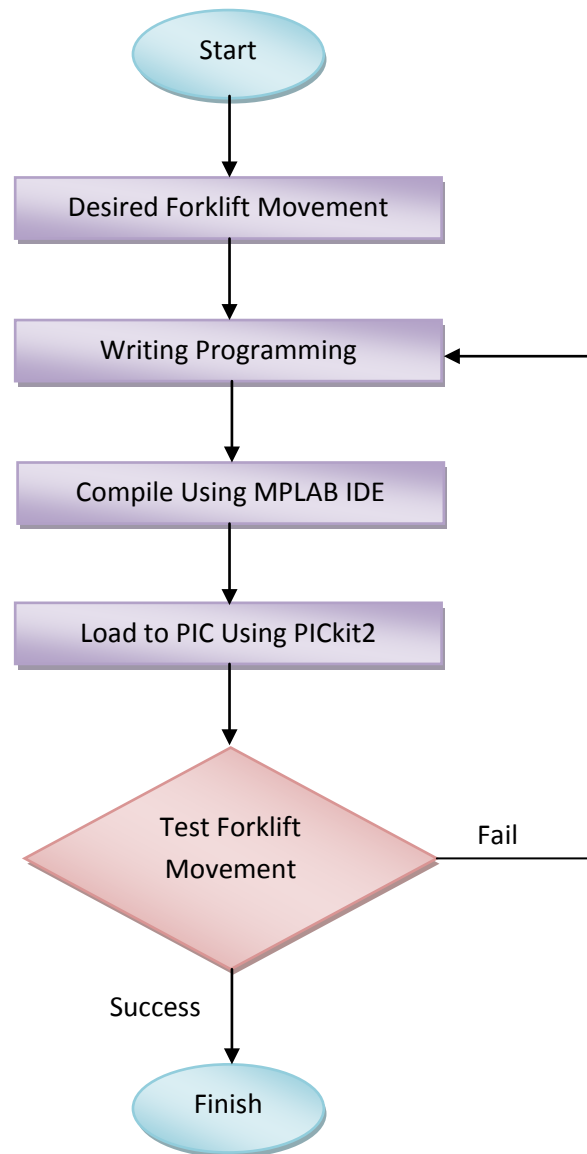


Figure 3.28: Software Programming Design Flow Chart

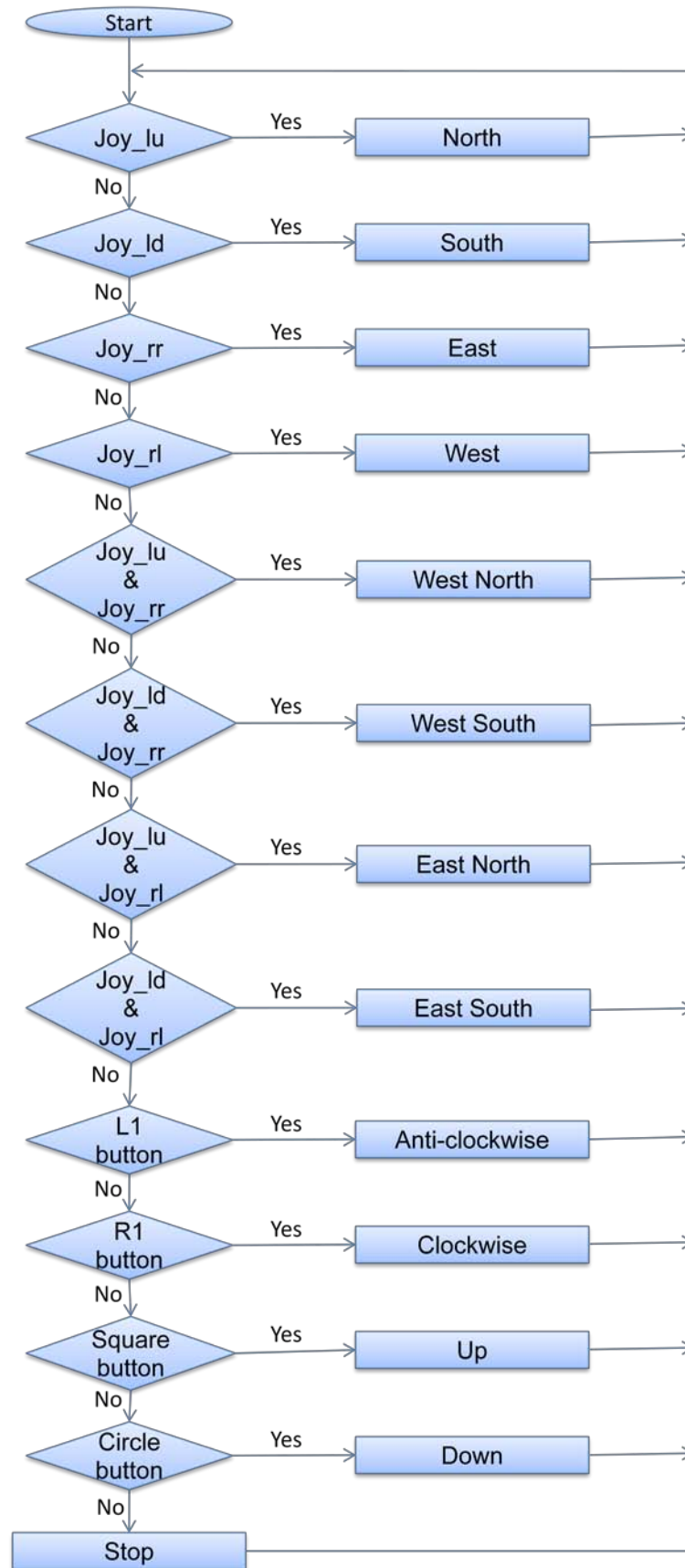


Figure 3.29: Flow Chart of Wireless Forklift with Omni-directional Movement Programming

Figure 3.29 shows the complete flow chart of Wireless Forklift with Omni-Directional Movement. Forklift will not make any movement if any button of PS2 wireless controller does not press. To make this forklift can lift up and down the light object; square button was assigned to the lift up process while the lift down process, circle button was assigned.

The movement of omni-directional movement has been assigned by using two joysticks. Left joystick was assigned to make forward (north), and backward (south) direction while to the left (west), and right (east) direction right joystick has been assigned. However to make the north east, north west, south east, and south west direction the both joystick has been assigned to used together.

Last but not least is the clockwise and anticlockwise movement. L1 button has been assigned to do the anticlockwise process and R1 button to do the clockwise process.

3.4 SUMMARY OF CHAPTER 3

In this chapter was discussed about the mechanical structure design, electronic and circuit design and last but not least programming design of the Wireless Forklift with Omni-Directional Movement.

In mechanical design part, the forklift with the specification discussed above was successfully done. In electronic and circuit design section, various electronic components, module and circuits employed in this wireless forklift were discussed.

Furthermore in the programming part, the selection for software to do programming was determined and flow chart for the movement of Wireless Forklift with Omni-Directional Movement was discussed.

CHAPTER 4

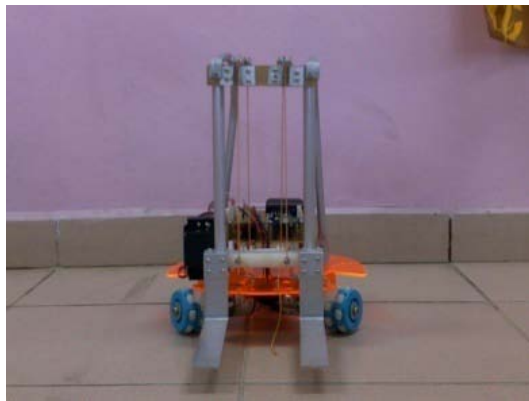
RESULT AND DISCUSSION

4.1 INTRODUCTION

The result of Wireless Forklift with Omni-directional Movement shall be explained in this chapter. This chapter also discusses about the problems that are encountered throughout the completion of this project. This project has been executed step by step. The first step that been executed is to make this project can move in the omni-directional movement. After this objective have achieved, the second step is to control this project using PS2 wireless controller and finally is to lift up and carry the light object.

4.2 FINAL HARDWARE DESIGN

The final hardware design of Wireless Forklift with Omni-directional Movement is illustrated in Figure 4.1



Front view



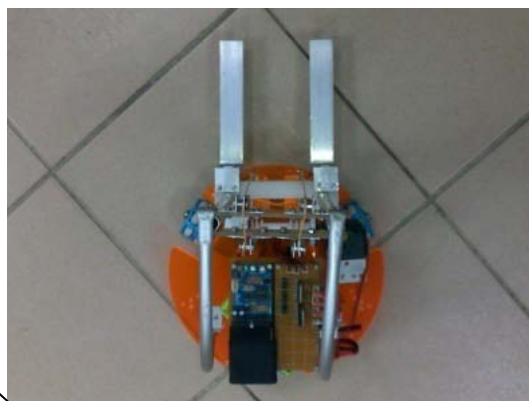
Back view



Right view



Left view



Plan view



Isometric view

Figure4.1: Different view of Wireless Forklift with Omni-directional Movement

4.3 THE MOVEMENT OF OMNI-DIRECTIONAL MOVEMENT

The first step is to make this project can move in the omni-directional movement. To do this, first we need to check connectivity of the circuit before try simple programming to this project which is to make this project clockwise and anti clockwise. After simple programming has succeeded, the programming of ten movements is implementing to this project.

However the first programming of movement is not including the controller, it is automated. After the programming has been confirmed, then next step is to make this project can control using PS2 controller. Figure 4.2 shows the picture of wireless forklift with omni-directional movement at this stage step.

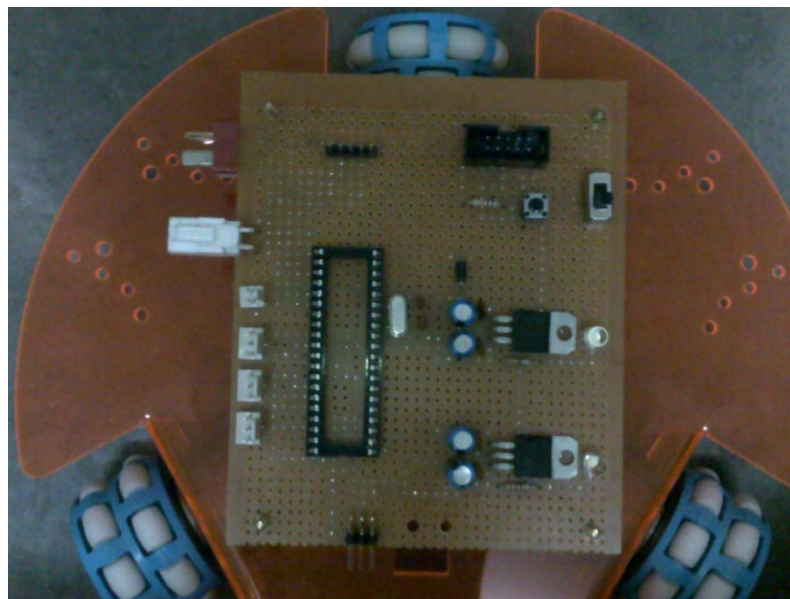


Figure4.2: Wireless Forklift at Early Stage

The forklift was able to move north (forward), south (backward), west (turn left), east (turn right), north east, north west, south east, south west, clockwise and anticlockwise. Total all of the movement are ten movements. The directions of the movement are shown on the Figure 4.3 below.

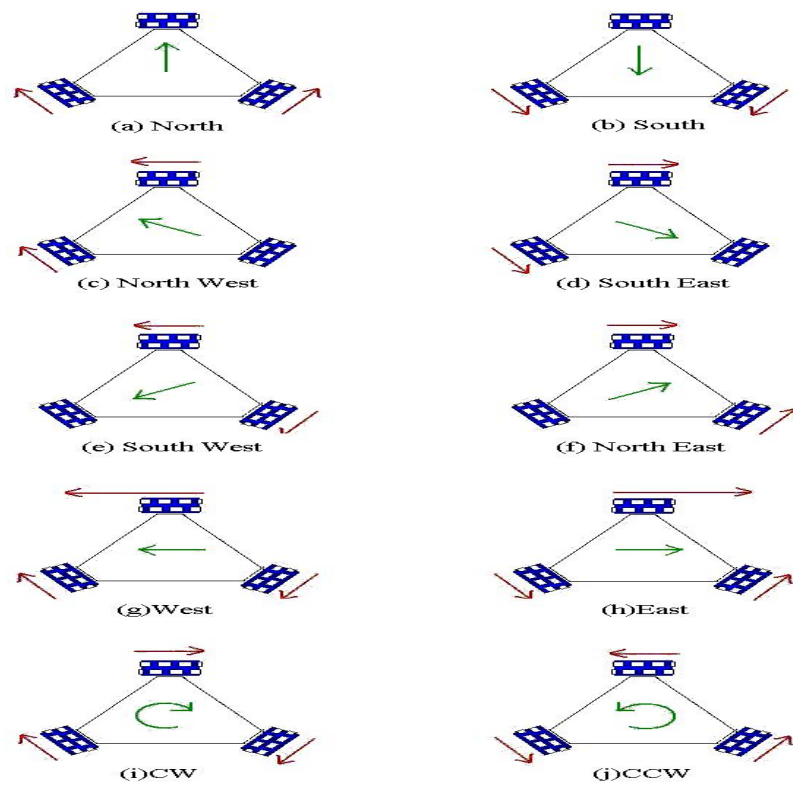


Figure 4.3: Direction of the forklift by using transwhee

4.4 MOVEMENT OF PICK AND PLACE LIGHT OBJECT

The next step is to make the forklift can pick and place the light object. This step only complicated when the hardware does. Before implement software into the hardware, first we need to test the programming at servo motor. In this case, servo motor has already been modifying to turn 360 degree. After modifying, Servo Motor is act like a DC motor. The next step is implementing with the hardware, Figure 4.4 shows the step to lift up a light object.

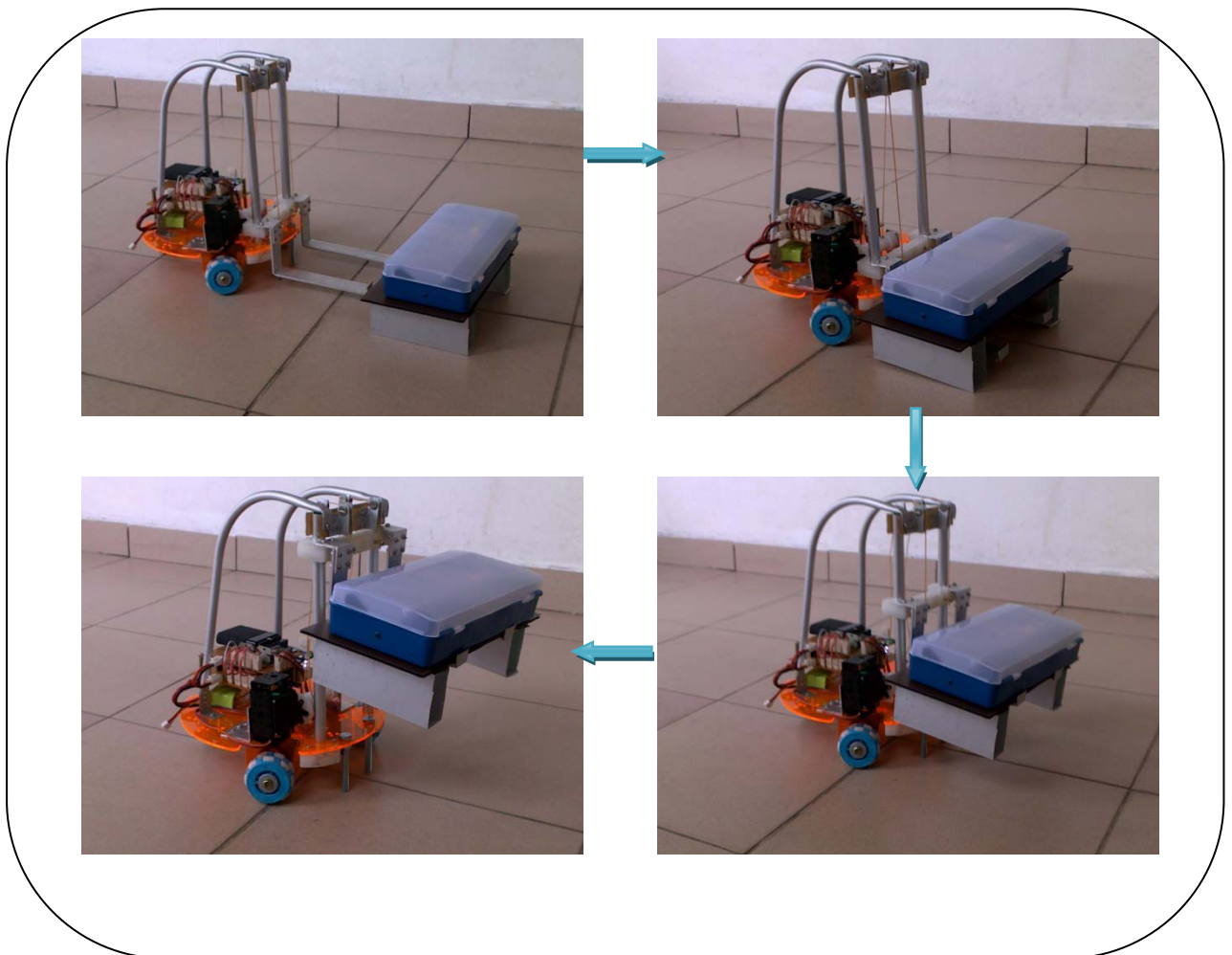


Figure4.4: Flow of Wireless Forklift to Lift Up a Light Object

4.5 DISCUSSIONS

Even though this project was successfully completed, but there are some challenging parts throughout this project. The first and foremost is when to start the project, the problem is what components to be used and the circuits design, what the suitable base to be used and the programming that have to write. The problem has been overcome by doing research on thesis, journal, and information from internet.

The next problem is during the circuit design. After completing the soldering circuits, motor driver circuit has some problem that cannot send the desired output and there is a short circuit on that motor driver circuit. Some troubleshoot has been done vigorously to the motor driver circuit and the problem is identified. However the circuit still can produce the desired output. Next step is tried to change the connection of the motor driver circuit to the PIC and the problem has been solve. After do some more investigation, the circuit has no problem but the problem is the programming due to some setting does not include.

Next, the programming of the movements of forklift is coded. The first stage of programming is to make the movements forklift which is forward (north), backward (south), left (west), and right (east) direction. Eventually the programming for the north and south direction was success but there is an error west and east direction. The actual problem has solved after change the tyre of forklift.

Last challenging during doing this project is the tools that used to make the mechanical structure for the fork (mechanism to lift up and down). There is a machine that provided by faculty but faculty does not provided the learning to use that machine. Help from Robocon team member has been asked to teach how to use that machine and the mechanical structure has successfully done.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Project has been successfully carried out to design, create and build the Wireless Forklift with Omni-Directional Movements. It was able to pick and place a light object to the destination and capability of omni-directional movement which is forward (north), backward (south), left (west), right (east), north east, north west, south east, south west, clockwise, and anticlockwise direction. This also can be controlled using wireless controller which is using PS2 wireless controller.

It can be concluded that all objectives that has been discussed in chapter 1 was successfully been implemented and achieved by the end of this project. The forklift is capable to pick and place a light object with moving in the omni-directional movements and control by using PS2 wireless controller.

5.2 RECOMMENDATION

For the future works, some modification can be implemented to enhance the capability of this project. On the mechanism part, larger base are needed to make this forklift more stable and more weight. With the larger base, the forklift can pick and place a more weight objects. Besides that, the system that uses to lift up and down the object can be changed instead of using rope. It can be replace such as gear system and screw system to make it more like an actual forklift. Furthermore, there are more wireless controller can be used such as ZigBee controller, RF controller, and Bluetooth controller (using computer or laptop).

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APPENDIX

APPENDIX A: Source Code

```

#include <pic.h>           //include the PIC microchip header file

//      configuration
__CONFIG(0x3FA2);         //configuration word register 1 for the microcontroller
__CONFIG(0x3FBC);         //configuration word register 2 for the microcontroller

//      define
#define lmspeed            CCPR1L    //left motor driver speed control pin
#define lmotor1            RD6       //left motor driver input1
#define lmotor2            RD7       //left motor driver input2
#define rmspeed            CCPR3L    //right motor driver speed control pin
#define rmotor1            RB3       //right motor driver input1
#define rmotor2            RD5       //right motor driver input2
#define bmspeed            CCPR2L    //back motor driver speed control pin
#define bmotor1            RD3       //back motor driver input1
#define bmotor2            RD2       //back motor driver input2

#define servo RB0

//skps protocol
#define p_select           0
#define p_joyl             1
#define p_joyr             2

```

#define p_start	3
#define p_up	4
#define p_right	5
#define p_down	6
#define p_left	7
#define p_l2	8
#define p_r2	9
#define p_l1	10
#define p_r1	11
#define p_triangle	12
#define p_circle	13
#define p_cross	14
#define p_square	15
#define p_joy_lx	16
#define p_joy_ly	17
#define p_joy_rx	18
#define p_joy_ry	19
#define p_joy_lu	20
#define p_joy_ld	21
#define p_joy_ll	22
#define p_joy_lr	23
#define p_joy_ru	24
#define p_joy_rd	25
#define p_joy_rl	26
#define p_joy_rr	27
#define p_con_status	28
#define p_motor1	29
#define p_motor2	30

```
void init(void);  
void lm_run(unsigned char dir);  
void rm_run(unsigned char dir);  
void bm_run(unsigned char dir);
```

```

void left(void);
void right(void);
void backward(void);
void forward(void);
void clockwise(void);
void anticlockwise(void);
void stop(void);
void deg_30(void);
void deg_120(void);
void deg_240(void);
void deg_330(void);
void delay(unsigned long data);

void uart_send(unsigned char data);
unsigned char uart_rec(void);
unsigned char skps(unsigned char data);
void skps_vibrate(unsigned char motor, unsigned char value);

void main(void)
{
    unsigned char up_v, down_v, left_v, right_v;

    init();                //initialize microcontroller
    stop();

    while(1)
    {
        //read joy stick value process
        up_v=skps(p_joy_lu);
        down_v=skps(p_joy_ld);
        left_v=skps(p_joy_rl);
        right_v=skps(p_joy_rr);

        if(skps(p_up)==0)

```

```

    {
        lmspeed=rmspeed=255;
        //assign speed to respective motor pwm pin
        bmspeed=0;
        forward();
    }
else if(skps(p_down)==0)
    {
        lmspeed=rmspeed=255;
        bmspeed=0;
        backward();
    }
else if(skps(p_left)==0)
    {
        bmspeed=255;
        lmspeed=rmspeed=190;
        left();
    }
else if(skps(p_right)==0)
    {
        bmspeed=255;
        lmspeed=rmspeed=190;
        right();
    }
else if(skps(p_l1)==0)
    {
        anticlockwise();
    }
else if(skps(p_r1)==0)
    {
        clockwise();
    }
else if(skps(p_square)==0)
    {

```

```

        servo=1;                //set servo pin high
        delay(70);
        servo=0;                //set servo pin low
        delay (2635);
    }
else if(skps(p_circle)==0)
    {
        servo=1;                //set servo pin high
        delay(317);
        servo=0;                //set servo pin low
        delay (2385);
    }
else if(up_v>0)
    {
        if(right_v>0)
            {
//assign speed to respective motor pwm pin
                bmspeed=rmspeed=up_v+140;
                lmspeed=0;
//assign the direction respective motor to
                bm_run(0);
                rm_run(0);
            }
        else if(left_v>0)
            {
                bmspeed=lmspeed=up_v+140;
                rmspeed=0;
                bm_run(1);
                lm_run(1);
            }
        else
            {
                lmspeed=rmspeed=up_v+140;
                bmspeed=0;
            }
    }

```

```

        forward();
    }
}
else if(down_v>0)
{
    if(right_v>0)
    {
        bmspeed=rmspeed=down_v+140;
        lmspeed=0;
        bm_run(1);
        rm_run(1);
    }
    else if(left_v>0)
    {
        bmspeed=lmspeed=down_v+140;
        rmspeed=0;
        bm_run(0);
        lm_run(0);
    }
    else
    {
        lmspeed=rmspeed=down_v+140;
        bmspeed=0;
        backward();
    }
}
else if(right_v>0)
{
    bmspeed=right_v+140;
    lmspeed=rmspeed=right_v+90;
    right();
}
else if(left_v>0)
{

```

```

        bmspeed=left_v+140;
        lmspeed=rmspeed=left_v+90;
        left();
    }
else
{
    stop();
}
}

void init()
{
    ADCON1 = 0b00011111;           //set ADx pin digital I/O
    TRISB = 0b00000000;           //configure
    PORTB I/O direction
    TRISD = 0b00000000;           //configure
    PORTC I/O direction
    TRISC = 0b10000000;
    PORTB = 0x00;

    //Setup up PWM operation
    PR2=255;                       //Set PWM period
    CCP1CON = 0b00001100; //Configure CCP1CON to on the PWM1 operation
    CCP2CON = 0b00001100; //Configure CCP2CON to on the PWM2 operation
    CCP3CON = 0b00001100; //Configure CCP3CON to on the PWM3 operation
    T2CON = 0b00000100;

    lmspeed = 0;                   //Clear left motor speed
    rmspeed = 0;                   //Clear right motor speed
    bmspeed = 0;                   //Clear back motor speed

    //setup USART
    SPBRG = 0x81;                  //set baud rate to 9600
    for 20Mhz

```

```

BRGH = 1;                //baud rate high speed option
TXEN = 1;                //enable transmission
TX9 = 0;
CREN = 1;                //enable reception
SPEN = 1;                //enable serial port
RX9 = 0;
RCIE = 0;                //disable interrupt on eachdata received

```

```

}

```

```

// uart function

```

```

void uart_send(unsigned char data) //function to send out a byte via uart
{
    while(TXIF==0);            //wait for previous data to finish send out
    TXREG=data;                //send new data
}

```

```

unsigned char uart_rec(void)      //function to wait for a byte receive from uart
{
    unsigned char temp;
    while(RCIF==0);            //wait for data to received
    temp=RCREG;
    return temp;                //return the received data
}

```

```

// skps function

```

```

unsigned char skps(unsigned char data) //function to read button and joystick
{
    //information on ps controller
    uart_send(data);
    return uart_rec();
}

```

```

void skps_vibrate(unsigned char motor, unsigned char value)

```

```

{
    //function to control the vibrator motor
    uart_send(motor);                                //on    ps
controller
    uart_send(value);
}

void lm_run(unsigned char dir)
    //Function to run the left motor
{
    lmotor1=dir;
        //assign variable "dir" to left motor pin 1
    lmotor2=!dir;
        //assign the oppesite value of "dir" variable to left motor pin 2
}

void rm_run(unsigned char dir)
    //Function to run the right motor
{
    rmotor1=dir;
        //assign variable "dir" to right motor pin 1
    rmotor2=!dir;
        //assign the oppesite value of "dir" variable to right motor pin 2
}

void bm_run(unsigned char dir)
    //Function to run the back motor
{
    bmotor1=!dir;
        //assign variable "dir" to back motor pin 1
    bmotor2=dir;
        //assign the oppesite value of "dir" variable to back motor pin 2
}

```

```
void forward(void)
    //Function to run Flexibot 0 degree
{
    lm_run(1);
    //assign the direction to respective motor
    rm_run(0);
}

void backward(void)
    //Function to run Flexibot 180 degree
{
    lm_run(0);
    rm_run(1);
}

void right(void)
    //Function to run Flexibot 270 degree
{
    bm_run(0);
    lm_run(0);
    rm_run(0);
}

void left(void)
    //Function to run Flexibot 90 degree
{
    bm_run(1);
    lm_run(1);
    rm_run(1);
}

void stop(void)
    //Function to stop the motor
{
```

```

    lmotor1=0;
    lmotor2=0;
    rmotor1=0;
    rmotor2=0;
    bmotor1=0;
    bmotor2=0;
}

void clockwise(void)
    //Function to run Flexibot clockwise
{
    lmspeed=rmspeed=bmspeed=200;
    lm_run(1);
    rm_run(1);
    bm_run(0);
}

void anticlockwise(void)
    //Function to run Flexibot anticlockwise
{
    lmspeed=rmspeed=bmspeed=200;
    lm_run(0);
    rm_run(0);
    bm_run(1);
}

//    delay functions
void delay(unsigned long data)
    //delay function, the delay time
{
    //depend on the given value
    for( ;data>0;data-=1);
}

```